

Designing Optimal Sampling Networks, Fixed and Adaptive for Ocean Forecast Modeling

Paola Rizzoli, P.I.

Dept. of Earth, Atmos. & Planetary Sci., MIT, 54-1416,
77 Massachusetts Ave. Cambridge, MA 02139

Phone: 617-253-2451 Fax: 617-253-4464 Email: rizzoli@mit.edu

Award Number: N00014-06-1-0290

LONG TERM GOAL

The overall long term goal is to develop innovative, practical and efficient methodologies for the design of fixed and adaptive oceanic platforms, eulerian and lagrangian, such as fixed moorings, profiling moorings, gliders, drifters, AUVs.

OBJECTIVES

The main objective is to develop this methodology for the Gulf of Maine/Georges Bank (GM/GB) region where an integrated model system has been developed at the University of Massachusetts at Dartmouth centered around the Finite-Volume Coastal Ocean circulation Model (FVCOM).

APPROACH

The technical approach will be to test the available data assimilation packages, i.e. Reduced Rank Kalman Filter (RRKF); Ensemble Kalman Filter (EnKF); Ensemble Square Root Kalman Filter (EnSRF) and the Ensemble Transform Kalman Filter (ETKF) in the idealized test-cases outlined in the report. Successively, the filters will be adapted to FVCOM in the GM/GB configuration for coastal circulation prediction and adaptive sampling studies.

WORK COMPLETED

The grant started on **January 1, 2006**. Postdoctoral Associate Dr. Jun Wei has joined the group on **September 1, 2006**. The idealized tests completed are discussed in the main report.

RESULTS

Same as above

IMPACTS/ APPLICATIONS

The potential future impacts of adaptive sampling in an oceanographic context, where they are still non-existent, will be comparable to the enormous impacts it has had in meteorology.

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 30 SEP 2006		2. REPORT TYPE		3. DATES COVERED 00-00-2006 to 00-00-2006	
4. TITLE AND SUBTITLE Designing Optimal Sampling Networks, Fixed and Adaptive for Ocean Forecast Modeling				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Massachusetts Institute of Technology, Dept. of Earth, Atmos. & Planetary Science, 77 Massachusetts Avenue, Cambridge, MA, 02139				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 3	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

RELATED PROJECTS

None

REFERENCES

- Buehner, M. and P. Malanotte-Rizzoli, 2003a . Reduced-rank Kalman filters applied to an idealized model of the wind-driven ocean circulation. *Journal of Geophysical Research*, **108**, no.C6, 3192, 10.1029/2001JC00873.
- Buehner, M., P. Malanotte-Rizzoli, A. J. Busalacchi and T. Inui, 2003b . Estimation of the tropical Atlantic circulation from altimetry data using a reduced-rank stationary Kalman filter. *Interhemispheric water exchanges in the Atlantic ocean*, Elsevier Oceanographic series, G. Goni and P. Malanotte-Rizzoli eds., **68**, 193–212.
- Bishop, C.H., B.J.Etherton and S.J.Majunder, 2001. Adaptive sampling with the Ensemble Transform Kalman Filter. Part I : theoretical aspects *Mon. Wea. Rev.*, 129, 420-439
- Burchard, H., 2002. Applied turbulence modeling in marine waters. *Springer:Berlin-Heidelberg-New York-Barcelona-Hong Kong-London-Milan Paris-Tokyo*, 215pp.
- Chen, C., H. Liu, and R. Beardsley, 2003. An unstructured grid, finite-volume, three-dimensional, primitive equations ocean model: Application to coastal ocean and estuaries. *Journal of Atmospheric and Ocean Technology*, 20 (1), 159–186.
- Chen, C, G. Cowles and R. C. Beardsley, 2006a. An unstructured grid, finite-volume coastal ocean model: FVCOM User Manual. Second edition, SMAST/UMASSD Technical Report-06-0602, pp315
- Chen, C, R. C. Beardsley and G. Cowles, 2006b. An unstructured grid, finite-volume coastal ocean model (FVCOM) system. Special Issue entitled “Advance in Computational Oceanography”, *Oceanography*, 19(1), 78-89.
- Chen, C., H. Huang, R. C. Beardsley, H. Liu, Q. Xu, and G. Cowles, 2006c. A finite-volume numerical approach for coastal ocean circulation studies: comparisons with finite-difference models. *Journal of Geophysical Research*, in press.
- Chen, C., R. C. Beardsley, Q. Xu and R. Limeburner, 2006d. Tidal Dynamics in the Gulf of Maine and New England Shelf: An Application of FVCOM. *Deep Sea Research II: GLOBEC/GB Special Issue*, in revision.
- Galperin, B., L. H. Kantha, S. Hassid, and A. Rosati, 1988. A quasi-equilibrium turbulent energy model for geophysical flows. *Journal of the Atmospheric Sciences*, 45, 55–62.
- Huang, H., C. Chen, G. Cowles, R. C. Beardsley, and K. Hedstrom, 2006a. Sensitivity of the numerical solution to unstructured triangular grids: A validation experiment of FVCOM for the Rossby equatorial soliton. *Journal of Atmospheric and Oceanic Technology*, in revision.

Huang, H., C. Chen, R. C. Beardsley, and K. Hedstrom, 2006b. Validation experiments of FVCOM for the wind-driven flow in an elongated rotating basin: A comparison with analytical solution. *Journal of Atmospheric and Oceanic Technology*, to be submitted.

Lyu, S.-J., P. Malanotte-Rizzoli, D. McLaughlin and D. Entekhabi, 2006 a, A comparison of data assimilation results from the deterministic and stochastic ensemble Kalman filters, in revision for *J. Atmos. Ocean. Tech.*

Lyu, S.-J., P. Malanotte-Rizzoli, J. A. Hansen, D. McLaughlin and D. Entekhabi, 2006b, Optimal fixed and adaptive observation arrays in an idealized model of the wind-driven ocean circulation, submitted to *J. Atmos. Ocean. Tech.*

Mellor, G. L. and T. Yamada, 1982. Development of a turbulence closure model for geophysical fluid problem. *Reviews of Geophysics and Space. Physics*, 20, 851–875.

Smagorinsky, J., 1963. General circulation experiments with the primitive equations, I. The basic experiment. *Monthly Weather Review*, 91, 99–164.

Zang, X. and P. Malanotte-Rizzoli, 2003. A comparison of assimilation results from the Ensemble Kalman filter and the Reduced-Rank Extended Kalman filter. *Nonlinear Processes in Geophysics*, **10**, 6,477–6,491

HONORS

Membership of the American Geophysical Union, May 2006